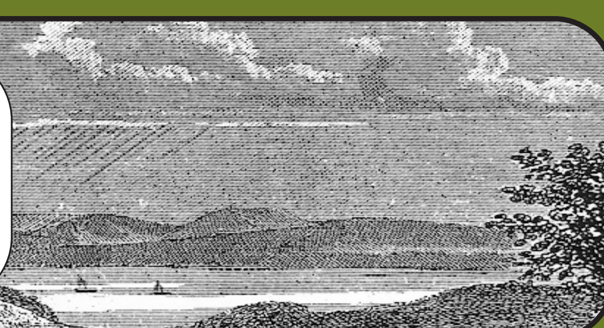
HABITAT QUALITY AND BIOLOGICAL INTEGRITY ASSESSMENT FOR THE NORTHEAST AND NORTHWEST BRANCHES OF THE ANACOSTIA RIVER



STATE OF MARYLAND DEPARTMENT OF NATURAL RESOURCES

CHESAPEAKE BAY AND
WATERSHED PROGRAMS
MONITORING AND
NON-TIDAL ASSESSMENT

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Anacostia River Project Monitoring Results

This work was conducted for the U.S. Army Corps of Engineers by the Maryland Department of Natural Resources (DNR) under contract No. DACW31-00-P-0484

Introduction

The overall objective of this project was to characterize the physical habitat and biological integrity of the lower reaches of the Northeast and Northwest Branches of the Anacostia River. This study was requested and sponsored by the U.S. Army Corps of Engineers (ACOE) to assist in determining the potential for restoration of physical habitat and biological community improvements to streams in these watersheds. Sampling was also conducted at the request of the ACOE in Big Elk Creek as a baseline for proposed stream projects.

Methods

All data were collected between March and October 2000 using DNR's Maryland Biological Stream Survey (MBSS) methods (Kazyak 2000). Quality control and quality assurance procedures for this project followed the MBSS QA/QC methods as outlined in Appendix A. These procedures have been accepted by the U.S. Environmental Protection Agency and meet all requirements as outlined in “The Guidelines and Specifications for Preparing Project Plans”, EPA QAMS 005/80. Sampling was conducted at a total of eight non-tidal stream sites for this study. The full suite of MBSS data were collected from six sites. The full suite of MBSS data includes fishes, benthos, physical habitat, water chemistry and land use. Only selected biological data were collected from the two remaining sites. Five sites were located in the Northeast and Northwest branches of the Anacostia River. We also sampled two additional sites, one each in Mattawoman Creek and Henson Creek, that were selected by the ACOE as reference sites. One other site was sampled to characterize the biological integrity and biodiversity of Big Elk Creek. Table 1 shows the location, site names, and data collected at each site.

The five sites on the Northeast and Northwest Branches of the Anacostia River were sampled to examine differences in physical habitat quality and quantity and their influences on biological production and integrity. Figure 1 shows the locations of the stream sites sampled in the Anacostia watershed. Prior to sampling, ACOE and MBSS personnel conducted a brief visual examination of the physical habitat in the proposed habitat improvement project area in the Northeast and Northwest Branches of the Anacostia River. During this field reconnaissance, stable physical structure that would provide habitat for stream biota was considered to be lacking throughout the entire study area, with the exception of two areas on the Northwest Branch and one area on the Northeast Branch. One site on each branch (ANAC-301 on Northwest Branch and ANAC-303 on Northeast Branch) was sampled to document this observed lack of structural habitat. Two areas on Northwest Branch contained physical structure that was considered potentially beneficial to biota. One of these areas had considerably more stable physical structure than any other part of either branch. Site ANAC-302 was sampled in this area because it appeared to represent an area with the greatest potential for instream habitat quality and biological productivity/integrity. In another area on Northwest Branch, a well-developed riffle had been created when rip-rap was placed under the 38th Street bridge. Site ANAC-304 was sampled in this riffle area because it provided habitat that was considered potentially useful for benthic macroinvertebrates and benthic fish species. Only benthic macroinvertebrate and fish data were collected from this site because it was located close to the other two sites sampled on the Northwest Branch (ANAC-301 and ANAC-302) and, with the exception of riffle quality and embeddedness, the physical habitat was considered similar to that found at site ANAC-301. Therefore, collecting additional chemical, land use, and physical habitat data from the site would have been redundant and was not considered to be necessary. Stable physical structure was less available in Northeast Branch compared to Northwest Branch. Only one area with substantial structure was found. The habitat in this small area was created by a pipe (approximately 30 cm in diameter and five meters long) that partially crossed the stream channel. Only fish data were collected from this site (ANAC-305). Benthic macroinvertebrate habitat was not considered to differ from that found at the other site on the Northeast branch (ANAC-303). As with site ANAC-304, collecting chemical, land use, and physical habitat data from this site would have been redundant to the other site on this branch (ANAC-303) and was not considered to be necessary.

Table 1. Site locations and coordinates for all Anacostia River sites, reference sites, and the Elk River site sampled by MBSS in 2000.

Site	Location	MD 8-digit Watershed	Data Collected	Coordinates
ANAC-301	North West Branch, 100 m upstream from Rt.1 bridge	Anacostia River	All MBSS variables	38:56:50 N 76:56:57 W
ANAC-302	Northwest Branch, 300 m upstream from 38th Street	Anacostia River	All MBSS variables	38:56:57 N 76:57:32 W
ANAC-303	North East Branch, 100 m from Pavilion in Riverside Drive Park	Anacostia River	All MBSS variables	38:57:26 N 76:55:41 W
PRUT-201	Henson Creek, 400 m upstream from Temple Hill Road	Potomac River Upper Tidal	All MBSS variables	38:48:48 N 76:55:58 W
MATT-305	Mattawoman Creek, 200 m upstream from the Pomfret Road (Rt. 227)	Mattawoman Creek	All MBSS variables	38:37:09 N 77:02:47 W
ANAC-304	North West Branch, Under 38th St. Bridge	Anacostia River	Fishes, Benthos	38:56:55 N 76:57:25 W
ANAC-305	North East Branch, 300 m downstream from ANAC-303	Anacostia River	Fishes	38:57:18 N 76:55:45 W

BELK-301	Elkton, MD 200 m upstream from the Delaware Ave bridge	Big Elk Creek	All MBSS variables	39:36:33 N 75:49:14 W

Results and Discussion

Urban land use and run off from impervious surfaces have been widely shown to substantially influence stream chemistry, physical habitat and biological integrity. The Anacostia River watershed has experienced extensive urban development (Table 2). Urban land use covered greater than 35% of the watershed areas for each of the site catchments sampled in the Northeast and Northwest Branches of the Anacostia River. The Henson Creek site (PRUT-201) also had a very high proportion of urban land use in the site catchment (56%). The Mattawoman Creek site (MATT-305) and the Big Elk Creek (BELK-301) site had substantially less urban land use in the site catchments (11% and 4% respectively). The water quality, biota, and physical habitat at BELK-301 are more likely to be influenced by agricultural activities in the site catchment (61% agricultural land use) than by the small amount of urban land use (4%).

Table 2. Land use for catchments of sampled sites based on MRLC land use data.

WATERSHED	URBAN	AGRICULTURE	FOREST	IMPERVIOUS	OTHER	ACRES
ANAC-301	45.8%	19.7%	33.2%	14.6%	1.3%	33,336
ANAC-302	45.2%	20.0%	33.5%	14.4%	1.3%	32,674
ANAC-303	37.0%	19.3%	36.4%	12.5%	7.2%	46,777
PRUT-201	56.0%	14.6%	25.9%	21.1%	3.5%	5,889
MATT-305	11.0%	19.2%	54.5%	3.6%	15.4%	29,159
BELK-301	4.1%	61.0%	33.7%	1.4%	1.2%	37,731

Water Chemistry

Tables of chemistry measurements at three Anacostia River sites, the two reference sites and the Big Elk Creek site are in Appendices B1 and B2.

ANAC-301

pH and Acid Neutralizing Capacity (ANC)

Laboratory pH taken during spring sampling (7.36) and field measurements of pH taken during summer sampling (7.70) were both nearly neutral, suggesting that adverse acid conditions did not exist at this site. ANC was 1,038.3 μeq/L during spring sampling, indicating that the site is not susceptible to stress from acidic deposition and run-off. However, this ANC value was higher than most other sites that have been sampled previously by MBSS in the Potomac Washington Metropolitan Drainage Basin with less urban land use in the site catchment. The elevated ANC value at site ANAC-301 may be the result of sewage or other pollutants that originate from urban run off.

Nitrates, Sulfates and Dissolved Organic Carbon (DOC)
Nitrate measured during spring sampling (0.97 mg/L) indicates that nitrogen levels at baseflow are slightly elevated at this site compared to minimally disturbed sites. Sulfate was also slightly elevated (17.77 mg/L), an indication of urban runoff effects. DOC concentrations were 2.84 mg/L, suggesting that the influence of wetlands on water chemistry is minimal at the site.
Dissolved Oxygen (DO)
DO was 9.0 mg/L, well above the state water quality criterion of 5.0 mg/L (COMAR 1997). Relatively high DO levels along with relatively low nitrate indicates that eutrophication is not likely to be a stressor to aquatic biota.

Temperature
Measurements from the temperature logger which was placed at the site in early June and removed in mid-September showed a range of 22.1^{o} C (Appendix C1). The highest temperature of 33.6^{o} C was recorded on 12 June and surpassed the state water quality criterion for maximum temperature of 32^{o}C (COMAR 1997). This temperature may exclude certain aquatic biota from the site.

Overall, water chemistry and temperature measurements indicate that urban run-off may be influencing water quality at this site. However, with the exception of temperature effects, these influences appear to be relatively minor and would not be expected to substantially affect biota.

ANAC-302
pH and Acid Neutralizing Capacity
Laboratory pH was 7.67 and the field measurement of pH was 7.36. ANC was 1,092.4 µeq/L, indicating that the site is not susceptible to stress from deposition and acidic run-off. However, the ANC value was higher than values at most other sites that have been sampled previously by MBSS in the Potomac Washington Metropolitan drainage basin with less urban land use in the site catchment. Slightly elevated ANC values in this system may be the result sewage or other pollutants that originate from urban run off.

Nitrate, Sulfates and Dissolved Organic Carbon
Nitrate measured during spring sampling (0.95 mg/L) indicates that nitrogen levels at baseflow are slightly elevated at this site compared to minimally disturbed sites. Sulfate was also slightly elevated (17.30 mg/L), an indication of urban runoff effects. The DOC measurement of 3.13 mg/L suggested that the influence of wetlands on water chemistry is minimal at the site.

Dissolved Oxygen
DO (9.9 mg/L) was well above the state water quality criterion of 5.0 mg/L. Relatively high DO levels along with relatively low nitrates indicate that eutrophication is not likely to be a major stressor to biota.

Temperature
Temperature logger data are not available from this site. The logger was dislodged from the gabion where it was attached during spring sampling and not found during the summer visit. Since the two sites were close to one another on the same stream, the temperature logger data

from ANAC-301 should be applicable to this site. Temperature was within a normal range (21.0 ^{o}C) when taken during summer sampling (15 August).

Overall, water chemistry and temperature measurements indicate that urban run-off may be influencing water quality at this site. However, with the exception of temperature effects, influences appear to be relatively minor and would not be expected to substantially affect biota.

ANAC-303

pH and Acid Neutralizing Capacity

Laboratory pH was approximately neutral at 7.53 during the spring sampling period. However, field measurements show the pH was alkaline (8.92) and exceeded the Maryland water quality criterion of 8.5. This may be due to an algae bloom that could have result from eutrophication upstream of the site or influences from tidal waters downstream. ANC was 723.60 µeq/L, indicating that the site is not susceptible to acid stress.

Nitrate, Sulfates and Dissolved Organic Carbon

Nitrate measured during spring sampling (0.78 mg/L) indicates that nitrogen levels at baseflow are not elevated at this site compared to minimally disturbed sites. Sulfate was slightly elevated (15.23 mg/L). DOC was 3.9 mg/L. This is well below the 10 mg/L level where organic acids are considered to be a significant contributor to stream chemistry.

Dissolved Oxygen

DO (11.5 mg/L) was well above the state water quality criterion of 5.0 mg/L.

Temperature

Data from the temperature logger placed at the site in early June and removed in mid-September measured a range of 16.8 ^{o}C (Appendix C2). The highest temperature recorded (31.5 ^{o}C) was recorded on June 12 and is slightly below the state water quality criterion for maximum temperature (32 ^{o}C).

Overall, water chemistry and temperature measurements indicate that urban run-off influences water quality at this site. However, under baseflow conditions, these influences appear to be relatively minor and would not be expected to substantially affect biota.

Reference Sites

PRUT-201

pH and Acid Neutralizing Capacity

Laboratory pH was 7.11 and the field measurement was 7.6. ANC was 611.3 µeq/L, indicating that the site is not susceptible to acid stress.

Nitrates, Sulfates and Dissolved Organic Carbon

Nitrate was within the natural range (0.52 mg/L). Sulfate was slightly elevated (16.26 mg/L). DOC concentrations were 4.85 mg/L; well below the 10 mg/L level where organic acids become a significant contributor to stream chemistry.

Dissolved Oxygen

DO (8.2 mg/L) was above the state water quality criterion of 5.0 mg/L during the summer sampling period.

Temperature
Temperature logger data were not available from this site. The logger was dislodged from the root wad where it was attached during spring sampling and was not found during the summer visit. Temperature was within the normal range (25.4^{o} C) when taken during summer sampling. Overall, water chemistry and temperature measurements indicate that urban run-off may be influencing water quality at this site. However, these influences appear to be relatively minor and would not be expected to substantially affect biota at this site.

MATT-305

Spring water chemistry was not sampled at this site. Another site was sampled by MBSS approximately 1.5 miles upstream (CH-S-200-A206-99) during 1999. Although 1999 was a dry year, the water chemistry results from CH-S-200-A206-99 may represent something about the chemistry of site MATT-305 in 2000, due to the proximity of these sites to one another and the absence of major differences in land use or tributary confluences between the sites. Field samples of pH, dissolved oxygen, conductivity, and temperature were taken during the summer of 2000 at MATT-305.

pH and Acid Neutralizing Capacity
The spring pH at CH-S-200-A206-99 in 1999 was 5.7 and below the Maryland state water quality criterion of 6.5. Summer pH at MATT-305 in 2000 was 6.58. ANC was 32.1 μeq/L in 1999 indicating that this stream only has moderate protection from acid stress during episodes of acidic deposition and run-off.

Nitrates, Sulfates and Dissolved Organic Carbon
Nitrate in 1999 was within the natural range (0.61mg/L), indicating that nitrates are not a source of acidity for this stream and nutrient inputs from agriculture or urban development are limited. However, sulfate (15.48 mg/L) and DOC (10.5 mg/L) measurements were slightly elevated. Based on these levels, the land use surrounding the site, and the presence of wetlands in the watershed, organic inputs and acidic deposition are the two major sources of acidity for Mattawoman Creek.

Dissolved Oxygen
DO was (7.6 mg/L) above the state water quality criterion of 5.0 mg/L.

Temperature
No temperature loggers were deployed in Mattawoman Creek during 1999 or 2000. Temperature was within normal range (22^{o} C) when taken during summer 2000.

The influence of organic acids from wetlands may be influencing the ANC, pH, and DOC in Mattawoman Creek. The naturally occurring acidity from these wetlands may limit biological productivity and exclude taxa that do not tolerate acidity. Historically, wetlands may have influenced the water chemistry of the Anacostia River watershed in a similar way that they currently influence the chemistry of Mattawoman Creek. Presently, however, sewage and other inputs from urban run-off in the Anacostia River watershed may actually provide greater protection from acidic deposition compared to Mattawoman Creek where organic acids from wetlands lower the pH in the stream and little acid buffering capacity is present in the watershed's soil. The chemistry of the Anacostia River is therefore likely to provide favorable pH for a larger number of acid sensitive biological taxa compared to Mattawoman Creek. However, many acid tolerant taxa that flourish in wetland dominated systems may be excluded in the Anacostia due to competition from the cosmopolitan species.

BELK-301

pH and Acid Neutralizing Capacity

Laboratory pH was 7.43 and the 7.56 during the summer. ANC was 458.5 µeq/L, indicating that the site is not susceptible to acid stress.

Nitrates, Sulfates and Dissolved Organic Carbon

Nitrate (2.71 mg/L) and sulfate (13.49 mg/L) were slightly elevated, possibly due to agricultural runoff. DOC was 1.87 mg/L, well below the 10 mg/L level where organic acids become a significant contributor to stream chemistry.

Dissolved Oxygen

DO was 7.9 mg/L, within acceptable limits according to state water quality criterion (5.0 mg/L).

Temperature

Data from the temperature logger which was placed at the site in early June and removed in mid-September show a range of 12.2 ^{o}C (Appendix C3). The highest temperature recorded was 27.2 ^{o}C and did not exceed the state water quality criterion (32 ^{o}C).

Overall, water chemistry and temperature measurements indicate water quality was not a limiting factor for biota at site BELK-301 at the time of sampling. However, the moderately elevated levels of nitrates may be a stressor, especially to tidal portions of the system just downstream of the site.

Physical Habitat

The complexity and stability of stream habitat influences the abundance and diversity of biological communities. Important instream characteristics include: 1) quality and composition of the stream bottom, 2) diversity of depths and flows, and 3) quality and quantity of stable habitat for fish and attachment sites for benthic macroinvertebrates. Each site is discussed below. Appendix D shows the habitat assessment scores for the five Anacostia River sites, the two reference sites, and Big Elk Creek.

Anacostia River Sites

ANAC-301

The entire 75 meter length of the site was channelized. Vegetated riparian buffers were 25 meters wide on the right bank, and 20 meters wide on the left bank. ANAC-301 had the lowest habitat assessment scores of any site sampled for this project. Epifaunal substrate and riffle quality were rated as poor, and instream habitat and velocity/depth diversity had marginal ratings. Large boulders and spaces between rip-rap along the bank provided the majority of the habitat available to biota. Natural habitat in the form of woody structure was totally lacking. The number of woody structures found in sites previously sampled in the Potomac Washington Metro Drainage Basin averaged 3.5 per site. The statewide average was approximately 4 per site. Embeddedness at ANAC-301 was 60%, indicating limited surface area for macroinvertebrate and benthic fish production. The poor trash rating shows that human influences were abundant at the site.

ANAC-302
The entire 75 meter length of the site was channelized. Vegetated riparian buffer widths were 20 meters on the right bank and 30 meters on the left bank. Epifaunal substrate received a marginal rating and instream habitat received a sub-optimal rating. The remainder of the habitat scores were optimal. There were no woody structures found in this site, which illustrates the severe lack of *natural* instream habitat, cover, shading and surface area for fish and macroinvertebrates. However, man made structures including a utility crossing, rip-rap, and large pieces of metal provided more habitat structure at this site compared to the other site on the Northwest or the Northeast Branch site. In addition to providing substrate for biota, this structural complexity resulted in a greater diversity of depths and flows compared to other sites. This diversity may provide habitat for a greater variety of biota compared to areas with less structure. Embeddedness was 46% and was lower than at the other four sites sampled in the Anacostia watershed.

ANAC-303
The entire 75 meter length of the site was channelized. Vegetated riparian buffers were entirely absent and may be contributing to the potential for a variety of problems including erosion, higher nutrient inputs, increased sediment loading, lack of available woody structure, increased water temperatures and temperature fluctuations. Site ANAC-303 received a marginal rating for instream habitat. All other habitat assessment scores were in the sub-optimal range. No rootwads or instream woody debris were present. Embeddedness was 60%. The absence of woody structure and high level of embeddedness indicate that natural sources of habitat structure for fish and invertebrates are lacking. The poor trash rating is an indication that human influences were extensive at the site. The overall physical habitat at this site was very similar to the habitat at site ANAC-301 in the Northwest Branch.

Reference Sites

PRUT-201
The entire 75 meter length of the site was channelized. Vegetated riparian buffers were 30 meters wide on the right bank, and at least 50 meters wide on the left bank. This site had low habitat assessment scores, and were rated as marginal for instream habitat, epifaunal substrate, velocity/depth diversity and pool/glide/eddy quality. Riffle quality received a sub-optimal score. Woody structure was lacking. There were two instream rootwads and no instream woody debris, below the statewide and Potomac Washington Metro Drainage Basin averages. Embeddedness at site PRUT-201 was low (8%), indicating a high amount of substrate surface area potentially available for fish and macroinvertebrates. A marginal trash rating shows that human influences were apparent but not as extensive as at the Anacostia watershed sites.

MATT-305
This site showed no evidence of channelization for the entire length of the site. Vegetated riparian buffer widths were at least 50 meters wide on both banks. Pool/glide/eddy quality and epifaunal substrate received sub-optimal scores. Scores for instream habitat, velocity/depth diversity and riffle quality were rated as optimal. There was a large amount of woody structure found at the site (29 total pieces of wood), providing good natural habitat for fish and macroinvertebrates. This amount of woody structure is well above the statewide average of four pieces per site and the average of eight pieces per site for the Lower Potomac River Drainage Basin. Embeddedness was 25%, indicating that benthic habitat is relatively abundant.

BELK-301
There was no evidence of channelization at this site. The vegetated riparian buffer was at least 50 meters wide on both banks of the stream. The habitat assessment scores for epifaunal

substrate and instream habitat were marginal. Scores for velocity/depth diversity, pool/glide/eddy quality and riffle quality were optimal. The number of woody structures at this site was above the Elk River Drainage Basin average of six per site and the statewide average of four. There were eight instream woody debris and four each of dewatered woody debris, instream rootwads and dewatered rootwads. Embeddedness was only moderately high at 40%. A sub-optimal trash rating shows some evidence of human influences.

Fishes

Fishes collected at each site are listed in Appendix E. In general, greater numbers of fish species and individuals were present at sites with greater diversity and quantity of stable physical habitat structure. Migratory and game species were collected at some sites, but no rare or endangered species were collected at any site. A fish IBI was calculated for each site (Table 3). In addition, the percent of species expected to occur at each site was calculated given the distribution of fishes along with certain water chemistry, physical habitat, and landscape variables. Possible stressors to each site were diagnosed based on variables that were beyond tolerance thresholds for species expected to occur, but were absent (Table 4). The potential stressors identified were based on variables collected by MBSS on the day that the collection took place. Many variables not measured in this study may also be stressors to biota. In addition, temporally discrete sampling of water quality may have missed potentially important excursions which could have occurred during pulse events and may have adversely affected the biota.

Anacostia River Sites

A total of 33 of the 40 species found during this survey were collected at the sites sampled on the Northeast and Northwest branches of the Anacostia River. Relatively large numbers of fish species were collected at each site. This relatively high species richness may be attributable to the location of the sites near the Fall Line between two physiographic regions. This ecotone separates the Coastal Plain physiographic region from the Piedmont region. Some fish species are found exclusively in Coastal Plain or Piedmont streams but not both. However, streams on the Fall Line often contain species from both regions. Similarly, some species that are typically confined to tidal areas were collected at the Anacostia sites because the sites were close to the head of tide.

ANAC-301

The fish IBI rated the site as Good (4.25). A relatively large number of fishes (1,195) were collected representing 21 species. Sixty one three percent of the individuals are considered intolerant to environmental stressors and twenty three percent are considered tolerant. Three migratory species were collected including yellow perch, sea lamprey, and American eel. Two non-native species (common carp and bluegill) and two primarily estuarine fishes (mummichog and banded killifish) were also collected. The large majority of fishes collected from this site were taken in the vicinity of boulders and spaces between rip-rap along the bank which provided the bulk of the habitat for biota at this channelized site. Fifty seven percent of the expected fish species were present. Possible stressors based on absence of expected fish species at this site were poor riffle quality, low epifaunal substrate score, insufficient canopy shading, channel alteration, temperature, and percent impervious surface in the upstream site catchment.

ANAC-302

The fish IBI rated the site as Good (4.25). With the exception of yellow perch, brown bullhead, and mosquitofish, all species that were collected at site ANAC-301 were also collected at this site. However, there were 4,427 more individuals and seven more species collected at this relatively good quality habitat site compared to the poorer quality habitat site (ANAC-301). A total of 5,622 fishes were collected representing 28 species. Seventy-six percent of the fishes collected at the site are considered intolerant and 15% are considered tolerant. Migratory species included striped bass, sea lamprey, and American eel. Non-native species included smallmouth bass, largemouth bass, fathead minnow, common carp, and bluegill. Three of these species: striped bass, largemouth bass, and smallmouth bass are classified as gamefish. Greater species richness, abundance, and the addition of game fish at this site were likely due to the greater availability of structural habitat compared to site ANAC-301. Eighty eight percent of the expected fish species were present at this site. This higher percentage compared to site ANAC-301 is most likely due to the abundance of habitat structure at site ANAC-302. The structure provided living places for fishes and also created greater diversity of depths and flows to accommodate a greater variety of fish species. Possible stressors based on absence of expected fish species at this site were percent impervious surface in the site catchment, temperature, and channel alteration.

ANAC-303

The fish IBI rated the site as Good (4.00). A total of 1,199 fishes were collected, representing 18 species. The number of individuals and species were similar to site ANAC-301. Forty-five percent of the individuals collected are considered intolerant and seven percent are considered tolerant. Migratory species included sea lamprey and American eel. Bluegill was the only non-native species collected at this site. No game fish were collected. Sixty three percent of the expected fish species were present. Possible stressors based on absence of expected fish species at this site were high pH, insufficient canopy shading, channel alteration, temperature, and percent impervious surface in the site catchment.

ANAC-304

Seventeen species were collected in the riffle habitat located under the 38th Street bridge. The rocky riffles provided habitat for at least one species (blacknose dace) that was not collected at ANAC-301. Blacknose dace were also collected at ANAC-302 where riffle habitat was also better than at ANAC-301. Goldfish was the only species collected at this site that was not collected at either ANAC-301 or ANAC-302. Goldfish is an introduced species and probably does not indicate anything beneficial about the fish habitat at site ANAC-304. The collection of migratory species at ANAC-302 indicates that the rip-rap at site ANAC-304 may allow fish passage upstream from the tidal Anacostia River to the Northwest Branch at least as far as site ANAC-302.

ANAC-305

Fourteen species were collected in the vicinity of a pipe that provided structure and depth for fishes in the Northeast Branch. No species were collected at this site that were not collected at ANAC-303. Although actual counts of individuals were not conducted, banded killifishes, mummichogs, and swallowtail shiners appeared to be more abundant at site ANAC-305 compared to site ANAC-303.

Reference Sites

PRUT-201

The fish IBI rated the site as Fair (3.5). A total of 579 fishes were collected, representing 13 species. Seventy four percent of the individuals at the site are considered intolerant and 16% are considered tolerant. American eel was the only migratory species collected. Non-native species included largemouth bass and bluegill. One game fish species (largemouth bass) was found at the site, represented by two small individuals (<70 mm TL). Fifty seven percent of the expected fish species were present at this site. Channel alteration is one potential stressor identified based on absence of expected fish species at this site.

MATT-305

The fish IBI rated the site as Poor (2.5). A total of 103 fishes were collected, representing 11 species. None of the individuals collected at the site are considered intolerant and 59% are considered tolerant. With the exception of blacknose dace, all of the fish species collected at this site are tolerant of acidity. Three of the species (chain pickerel, eastern mudminnow, and tadpole madtom) have been found in larger numbers at sites with low pH (below 6.5) than at sites with alkaline or neutral pH. Sampling of the Mattawoman Creek watershed during 1995 and 1999 found many streams completely dry or consisting of only standing pools of water. These dry periods probably contributed substantially to the reduced fish numbers found at MATT-305 in 2000. Low flow periods may also explain the lack of intolerant species at this site. American eel was the only migratory species collected. Non-native species included largemouth bass and bluegill. Two species of gamefish (largemouth bass and chain pickerel) were collected. Sixty seven percent of the expected fish species were present at this site. No stressors were clearly identified based on absence of expected fish species. Absences of expected species were likely due to extremely dry periods and resultant low flows.

BELK-301

The fish IBI rated the site as Fair (3.90). An IBI score of 4.00 or higher is rated as Good. A total of 406 fishes were collected at Big Elk Creek representing 20 species. Forty-two percent are considered intolerant and 33% are considered tolerant. Migratory species collected during summer sampling at BELK-301included striped bass, sea lamprey, and American eel. Hickory shad in post spawning condition were also observed at this site during spring sampling. Non-native species included smallmouth bass, largemouth bass, and bluegill. Striped bass, largemouth bass, and smallmouth bass were the gamefish species collected at this site. Sixty nine percent of the expected fish species were present at this site. No stressors were identified based on the absence of expected fish species.

Benthic Macroinvertebrates

A total of 41 taxa of benthic macroinvertebrates were identified at the five Anacostia sites and two reference sites (not including the Big Elk Creek site) during this 2000 survey. Thirty-four percent of the taxa are considered tolerant and seven percent are considered intolerant. Appendix F lists the benthic macroinvertebrates collected at each site and their tolerance levels. The benthic macroinvertebrate IBI scores for each site are shown in Table 3.

Anacostia River Sites

The Anacostia sites had 25 of the 41 taxa identified. Taxa richness was relatively high. However, the assemblage was primarily composed of pollution tolerant midge larvae (Chironomidae). Although nitrate concentrations were not elevated when water samples were taken for this study, large numbers of tolerant taxa suggest periodic nutrient enrichment. The dominance of tolerant taxa and the absence of intolerant taxa, such as mayflies (Ephemeroptera) and stoneflies (Plecoptera), suggest severely degraded conditions for benthic macroinvertebrates at these sites. The degraded conditions for habitat may be attributed to the extensive channelization at these sites. Channelization reduced the amount of physical habitat available for benthos and most likely increased current velocities following rain storms. Unlike many fish species, benthic macroinvertebrates do not have the ability to move large distances to avoid stressful stream conditions. Therefore, increased current velocities would be likely to flush many benthic taxa out of the system.

ANAC-301
The benthic macroinvertebrate IBI rated the site Very Poor (1.86). Eighteen taxa were identified, half of which are classified as tolerant. Two genera of tolerant midge larvae (*Cricotopus*, and *Cricotopus/Orthocladius*) were dominant. Very little stable habitat for macroinvertebrate production (e.g. cobble, rootwads, woody debris, or aquatic plants) was available at this site, as illustrated by a very low epifaunal substrate habitat score (2 on a 0-20 scale).

ANAC-302
The benthic macroinvertebrate IBI rated the site Very Poor (1.86). Eleven taxa were identified. Sixty-five percent of the macroinvertebrates are considered tolerant. The tolerant midge larva *Cricotopus/Orthocladius* was the most abundant taxon. Although greater structure was available at this site to provide habitat for fishes, little stable habitat for macroinvertebrate production including cobble, rootwads, woody debris, or aquatic plants was available. In addition, although chemistry results from the time of sampling do not indicate conditions that would be expected to substantially affect biota, high urban land use in the site catchment suggests that water quality conditions may limit benthic macroinvertebrate production at this site.

ANAC-303
The benthic macroinvertebrate IBI rated the site Very Poor (1.29). A total of six taxa were identified; *Cricotopus/Orthocladius* was the dominant taxon. The low diversity of macroinvertebrates along with the absence of intolerant taxa and specialized feeders, such as scrapers and clingers, suggest severely degraded stream conditions for benthic macroinvertebrates.

ANAC-304
Although abundant benthic macroinvertebrate habitat was available at this site in the form of cobble and gravel, the benthic macroinvertebrate IBI rated the site Very Poor (1.57). A total of twelve taxa were identified. *Cricotopus/Orthocladius*, a genus of tolerant midge larva (Chironomidae), was the most abundant taxa. Chemical measurements from ANAC-301 and ANAC-302 suggested that the influence of water quality on biota should be relatively minor in the Northwest Branch. However, the very poor benthic IBI score at this Northwest Branch site, even with abundant habitat, suggests that water quality is probably having a severe negative impact on macroinvertebrates. Chemicals not measured in this study may have affected macroinvertebrates or chemical stress may occur in temporally discrete pulses that were not measured during site visits in 2000.

Reference Sites
The reference sites had a total of 22 of the 41 taxa found during this survey. Eighteen percent of the taxa are classified as tolerant to environmental stressors and none are classified as intolerant.

PRUT-201
The benthic macroinvertebrate IBI rated the site Very Poor (1.86). A total of eleven taxa were identified. *Cricotopus/Orthocladius* was the most abundant taxa. Despite relatively low riffle embeddedness (8%) and the presence of an extensive forested riparian buffer on the left bank of

the stream, the absence of intolerant taxa and the dominance of midge larvae (Chironomidae) indicate degraded stream conditions for macroinvertebrates. As with the Anacostia sites, channelization the stream at PRUT-201 may explain much of the habitat and macroinvertebrate findings. Low embeddedness may be due to flushing of fine substrate from riffles during high flow events. Such events may also move gravel and cobble and dislodge many invertebrates residing in the interstitial spaces between these substrate types. Leaves and wood from the forested riparian area that could provide food for many intolerant taxa of aquatic insects may also go under utilized because leaves and wood may not be retained in the system, but are instead flushed quickly downstream.

MATT-305

The benthic macroinvertebrate IBI rated the site Fair (3.00). A total of twelve taxa were identified. The majority of macroinvertebrates (82%) are considered moderately tolerant of stressors. Hydropsychid caddisflies (*Cheumatopsyche* and *Hydropsyche*) dominated the assemblage. Hydropsychids are ubiquitously distributed and abundant in high quality streams as well as moderately degraded systems. They are filter feeders and often abundant in streams with moderately elevated nutrient concentrations where they find abundant food. Many intolerant taxa of invertebrates may be absent as a result of periodic, extremely low flows in Mattawoman Creek and relatively low pH.

BELK-301

The benthic macroinvertebrate IBI rated the site Fair (3.22). A total of 16 taxa were collected and identified. *Cricotopus/Orthocladius* was the most abundant taxon. This was the only site to have two intolerant taxa of mayfly larvae (*Ephemerella* and *Isonychia*) and one intolerant taxon of midge larva (*Potthastia*).

Table 3. Fish and macroinvertebrate IBI scores for the Anacostia River sites, reference sites and the Elk River site.

Site	Fish IBI Score	Macroinvertebrate IBI Score
ANAC - 301	Good (4.25)	Very Poor (1.86)
ANAC - 302	Good (4.25)	Very Poor (1.86)
ANAC - 303	Good (4.00)	Very Poor (1.29)
PRUT - 201	Fair (3.50)	Very Poor (1.86)
MATT - 305	Poor (2.50)	Fair (3.00)
BELK - 301	Fair (3.90)	Fair (3.22)

Table 4. Possible stressors to fishes that were expected to occur at the Anacostia study sites, reference sites, and Big Elk Creek site.

Site	Percent Predicted Present	Species Predicted but Absent	Possible Stressors Identified Based on Tolerance of Predicted but Absent Species
ANAC-301	57%	blacknose dace	poor riffle quality, canopy shading
		central stoneroller	poor riffle quality, canopy shading, channel alteration
		common shiner	canopy shading
		longnose dace	poor riffle quality, canopy shading

		mottled sculpin	poor riffle quality, canopy shading, channel alteration, impervious, epifaunal habitat score, temperature
		northern hogsucker	poor riffle quality, canopy shading, channel alteration, impervious, epifaunal habitat score
ANAC-302	88%	central stoneroller	channel alteration, impervious
		mottled sculpin	channel alteration, impervious, temperature
ANAC-303	63%	central stoneroller	poor riffle quality, canopy shading, channel alteration, pH
		common shiner	canopy shading
		longnose dace	poor riffle quality, canopy shading
		mottled sculpin	poor riffle quality, canopy shading, channel alteration, temperature
PRUT-201	57%	eastern mudminnow	unknown
		white sucker	channel alteration
		pumpkinseed	channel alteration
BELK-301	69%	blacknose dace	unknown
		longnose dace	unknown
		river chub	unknown
		spottail shiner	unknown
MATT-305	67%	bluespotted sunfish	unknown
		creek chubsucker	unknown
		fallfish	unknown
		pirate perch	unknown
		redfin pickerel	unknown
		rosyside dace	unknown

Herpetofauna

Table 5 lists the herpetofauna identified at all study sites. Aquatic herpetofauna were classified as tolerant, intolerant, and moderately tolerant to habitat degradation based on empirical evidence of presence and absence of the species in association with human-related influences (Roth et al. 1999). At all sites sampled for this study, relatively few herpetofauna species were found compared to sites previously sampled by the MBSS.

Anacostia River Sites

A total of four aquatic species of herpetofauna were collected at the Anacostia River sites. Three of the four are considered tolerant. The only other species (Fowler's toad) is considered moderately tolerant.

Reference Sites

A total of six species of herpetofauna were found at the reference sites. All of the species are considered tolerant. The only salamander found in this study (Northern two-lined salamander) was found in Henson Creek (PRUT-201). Although herpetofauna richness was relatively low at all sites in this study, the Mattawoman Creek site (MATT-305) had the highest herpetofauna species richness (three species).

BELK-301

Two species of herpetofauna (green frog and pickerel frog) were found at the Big Elk Creek site. The pickerel frog is considered moderately tolerant and the green frog tolerant.

Table 5. Herpetofauna identified at Anacostia River sites, reference sites, and the Big Elk Creek site. NA indicates it is a terrestrial species, and a tolerance classification has not been assigned.

Species	**Tolerance Level**	***ANAC-301***	***ANAC-302***	***ANAC-303***	***PRUT-201***	***MATT-305***	***BELK-301***
Bullfrog	T	X			X	X	
Common Snapping Turtle	T	X					
Eastern Box Turtle	T					X	
Five-Lined Skink	NA		X				
Fowler's Toad	M			X			
Green Frog	T				X	X	X
Northern Two-	T				X		
Northern Water Snake	T			X			
Pickerel Frog	M						X

Conclusions/Recommendations

Cummins and Stribling (1991) conducted a habitat and biological assessment of streams in the Anacostia watershed in 1990. The study concluded that stress to biota in the lower Northeast and Northwest Branches of the Anacostia River were primarily related to habitat degradation. The present study conducted in 2000 also found that the primary stressor to the fish communities was habitat quality rather than stream chemistry. Findings from site ANAC-304 where extensive habitat for benthic macroinvertebrates was available indicated that episodic changes in water chemistry may be the most important causes of degraded conditions for benthic macroinvertebrates. Movement of bottom substrates during storms in this channelized system is probably also an important stressor to benthic macroinvertebrates.

Comparing the benthic macroinvertebrate findings from the 1990 study to the present study shows similarities in the dominant taxa (Chironomidae) and few or no intolerant EPT taxa. When differences in level of identification are taken into consideration, fewer taxa were collected in this study compared to the 1990 study. Tolerant taxa and Chironomids were also less dominant in the 1990 samples. Since urban land cover increased from 55,975 to 63,024 acres in the Anacostia watershed from 1990 to 1997 (Figure 2)(Maryland Office of Planning 1998), urban related influences to habitat and water quality may be possible reasons for differences observed in the benthic macroinvertebrate community between 1990 and 2000. However, differences in sampling and processing methods may also have contributed to the differences in benthic macroinvertebrate results.

Fish data from Cummins and Stribling (1991) and the present study were also compared. Findings from site #2 in the Northeast Branch were compared to our site ANAC-303 and site #10 in the Northwest Branch was compared to sites ANAC-301 and ANAC-302. Species richness and abundance were greater at all sites sampled by MBSS during 2000. This was probably due to subtle differences in sampling methods. Eastern silvery minnow was the only species collected in the 1990 Northeast Branch sampling that was not collected at site ANAC-303 in 2000. This was probably because the site sampled in 1990 was closer to tidally influenced waters where eastern silvery minnows are often abundant. A longear sunfish was collected in the Northwest Branch during 1990, but none were collected during 2000 sampling by the MBSS. Longear sunfish are abundant in portions of the Potomac River watershed and, as a result, may occasionally be found in the Anacostia watershed.

Although the fish and benthic macroinvertebrate assemblages of Mattawoman Creek were limited by periodic, low stream flow and acidity, Mattawoman Creek provides an excellent model for potential habitat improvements to the Anacostia River watershed. Abundant woody debris and rootwads are available to stabilize stream banks and provide living places for biota. Since the Northeast and Northwest Branches of the Anacostia River do not seem to experience acid stress or extremely low flow conditions as often as Mattawoman Creek, these streams are likely to benefit from better physical habitat. Fishes and benthic macroinvertebrates appear to be somewhat limited in the Northeast and Northwest Branches of the Anacostia River by channelization, urban run-off, and water quality. Despite a general paucity of stable habitat, fish diversity and abundance were relatively high throughout the system. This may be due to the influx of estuarine species from nearby tidal areas and the presence of species that were found on both the Coastal Plain and Piedmont physiographic regions. Although fish numbers were relatively high at all sites sampled, substantially greater numbers of species and individuals at ANAC-302 compared to other sites suggest that improving the habitat diversity and stability in other areas are likely to result in even greater fish diversity and abundance. Game and migratory species also benefit from habitat diversity and stability as illustrated by higher numbers at site ANAC-302 compared to other sites. Therefore providing habitat structure similar to that found at site ANAC-302 in other parts of the Anacostia watershed should result in greater game and non-game fish numbers and diversity. Conversely, the effects of water quality and channelization appear to have limited the benthic macroinvertebrate community to the extent that their biological integrity and productivity are not likely to benefit as much as the fish community from habitat improvements alone.

Benefits of forested riparian buffers along the Northeast and Northwest Branches of the Anacostia River may be limited by the channelized nature of the systems as they were in Henson Creek. Benefits of forested buffers can only be realized if woody debris and leaves that enter the stream from the forest are retained in the system long enough to provide food and habitat for biota. Retention of woody debris and allochthonous leaf input would likely provide the most ecological benefits to the system. However, these benefits are still limited for fishes and benthic macroinvertebrates in the Northeast and Northwest Branches of the Anacostia River by water chemistry that is dominated by highly variable and temporally fluctuating hydrographs associated with urban run off.

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Appendix A
QUALITY ASSURANCE

The purpose of this appendix is to outline QA/QC activities which are part of the MBSS. The appendix includes descriptions of documentation procedures, responsibility and accountability of project personnel, training requirements, data quality objectives, facilities and equipment, information management, and data quality assessment. To achieve the objectives of the MBSS, it is imperative that all project personnel follow the procedures and guidance provided in this chapter.

3.1 INTRODUCTION

Quality assurance and quality control (QA/QC) are integral parts of data collection and management activities of the MBSS. The QA program for the MBSS was designed to: 1) ensure that data are of known and sufficient quality to meet the project objectives, and 2) provide estimates of various sources of variance associated with the individual variables being measured.

To be effective, the QA program must continually monitor the accuracy, precision, completeness, comparability, and representativeness of the data during all phases of the program. Components of the MBSS QA program include:

- establishment of Data Quality Objectives (DQOs);
- thorough investigator training;
- identification of project protocols and guidelines;
- comprehensive field and laboratory data documentation and management;
- verification of data reproducibility; and
- instrument calibration.

3.2 DATA QUALITY OBJECTIVES

The establishment of Data Quality Objectives (DQOs) for the MBSS is necessary to specify how good MBSS data must be to support decision making, including the level of uncertainty that the state is willing to accept. DQOs specify:

- the problem to be resolved;
- the decision to be made;

- the inputs to the decision;
- the boundaries of the study;
- the decision rule; and
- the limits on uncertainty.

It is important to note that DQOs are target values for data quality and are not necessarily criteria for the acceptance or rejection of data.

Because many aspects of the MBSS have not been rigorously tested in Maryland waters, adequate information to fully develop DQOs for the MBSS does not currently exist. Therefore, the DQOs listed below represent a preliminary analysis of the needs and gross expectations for MBSS data. Results of the first round of the MBSS will be used to refine DQOs for future rounds of the MBSS.

3.2.1 Preliminary DQOs for the MBSS

3.2.1.1 The Problem to be Resolved

With continuing impacts of point source pollution and ever increasing pressure from non-point source pollution, there is an increasing need to manage the aquatic resources of the state effectively and in a holistic manner. To accomplish this task, information about the current status of lotic (flowing) waters in the state is necessary. Information about the relative impacts of anthropogenic stressors on aquatic resources is also necessary in order to prioritize enforcement, restoration, monitoring, and management efforts. Of special importance to the MBSS is the ability to segregate the effects of acidic deposition from other stressors.

3.2.1.2 The Decision to be Made

Data from the MBSS will be used to support management decisions. Examples of such evaluations/decisions include:

- a determination of the extent and magnitude of acid deposition impacts on stream biota in Maryland;
- an evaluation of the degree to which the flowing, non-tidal waters of Maryland have balanced, indigenous populations of biota as specified in the Clean Water Act;
- a determination as to whether existing fishery management practices are adequate

to protect important fish stocks;

- a determination as to whether specific waters of the state require further investigation of stressor sources and impacts;

- prioritization of watersheds for protection, restoration and/or enhancement;

- a determination as to which anthropogenic stressors need to receive intensified management and enforcement activities; and

- development of one or more validated biological indices for evaluation and monitoring of impacts from anthropogenic stresses.

3.2.1.3 Inputs to the Decision

Inputs to the above management decisions require specific biological, water quality, and habitat data collected in comparable fashion. Specific inputs include indices and population estimates which accurately depict the water quality, habitat quality, biological integrity, and fishability of Maryland streams and rivers.

3.2.1.4 Population of Interest

The current population of interest includes all non-tidal, 3rd order and smaller stream reaches of the State of Maryland, with the exception of non-wadable impoundments on 3rd order and smaller streams, and impoundments which substantially alter the riverine nature of the reach. In future years, the population of interest may be expanded to include 4th order and larger streams.

3.2.1.5 Comparability and Completeness

Comparability of data between field crews will be maximized by providing standardized training in MBSS techniques prior to sampling. Training requirements are specified by the Project Officer and included in the Scope of Work for each organization involved in field sampling. Training is mandatory for all participants of both the Spring and Summer Index Periods.

To utilize data from a given sampling site during analyses, all data included on the MBSS data sheets which pertains to the analysis being conducted must be validated, plus all appropriate site location data.

3.2.1.6 Decision Rule

The following initial decision rules were established to provide a basis for management actions related to non-tidal, flowing waters in Maryland:

1) Determination of the status of streams and rivers with regard to balanced, indigenous populations will be based on species richness and abundance, presence-absence of historically present species, presence of introduced species which are perceived as nuisances or have known adverse impacts on native species. Community data at a site will be compared with community data obtained from within the watershed and physiographic region. A stream or river reach will be considered impaired if one or more historically present top predators are absent from a stream, if undesirable introduced species have displaced native species, if species richness is less than 70% of species richness at comparable locations, if abundance of native populations at a site is substantially less than the abundance observed at other comparable locations within the watershed or physiographic region, or if water quality at a site is too poor to support native fish.

2) Characterization of fishability at a site will be based on habitat quality (ranked as supporting, partially supporting, or non-supporting), abundance of recreationally important species of catchable size, and abundance of juveniles of recreationally important species. Abundance of a species in a stream will be based on a comparison to the highest densities observed in a watershed or physiographic region. Sites having population abundances within 50% of reference locations will be classified as fishable, while sites having densities between 1 and 50% of reference densities will be classified as marginal. Sites with no recreationally important fish species will be classified as non-fishable.

3) A decision to consider further investigations to identify particular anthropogenic impact sources will be made if biotic indices change more than 25% between stream reaches or between two sites of the same stream reach.

4) Ranking of potential for restoration or enhancement of streams and rivers will be based on: ultimate habitat potential to support native and/or sportfish populations, any limiting factors to habitat or water quality, and degree of public access.

5) The importance of various anthropogenic stressors will be evaluated based on relationships observed between biological data and habitat, water quality, landuse analysis, or other appropriate indicators. An individual stressor should be considered to be a primary cause of impairment if it explains 25% or more of the variation in one or more biological indices within a watershed, ecoregion, or drainage.

6) Abundance and/or species composition estimates at a given sample site will be considered acceptable if overall capture efficiency exceeds 50%.

3.2.1.7 Limits to Uncertainty

Two important components of uncertainty are precision and bias. Precision and bias relate to the amount of random and systematic error, respectively, and are determined through the use of replication, performance evaluation samples of known composition, and confirmatory analyses by experts. As results from the initial round of the MBSS will provide a means of defining uncertainty, uncertainty limits are not included in this version of the sampling manual.

3.3 DOCUMENTATION

To ensure scientific credibility, study repeatability and cost effectiveness, all project activities of the MBSS need to be adequately documented. These activities include itinerary development, landowner contacts, adherence to sampling protocols, equipment calibration, field sampling, review of data sheets, field notes, information management, data quality assessment, data analyses, and interpretation of data. To minimize the possibility that needed documentation or data is not recorded, standardized forms and on-site verification of form completions by supervisory personnel should be employed as part of the MBSS. Each of the activities listed above is described in other sections of this manual, including documentation procedures and requirements.

3.4 RESPONSIBILITY AND ACCOUNTABILITY

The purpose of this section is to define the organizational structure and responsibilities of personnel involved in the MBSS. As multiple organizations are involved in the MBSS, adherence to the chain of authority and information outlined below is paramount to successful completion of the MBSS.

A number of personnel report directly to the Project Officer-- the Training Officer, the Quality Control Officer (QC Officer), the Field Crew Supervisor for each organization involved in field sampling, and the Data Management and Analysis Officer (DM Officer). Crew Leaders report to their respective Field Crew Supervisor for day to day activities and emergencies. The responsibilities of each of these personnel are described in the following sections.

3.4.1 Project Officer

The MBSS Project Officer has overall responsibility for successful completion of the MBSS. Specific duties of the Project Officer include selection of subordinates, direction and approval of training activities, contractor oversight, liaison with the public and resource agencies, document review, and peer review solicitation.

3.4.2 Training Officer

The Training Officer is responsible for training of all field sampling personnel. At the direction of the Project Officer, the Training Officer coordinates with the QC Officer and the Field Program Leader to implement remedial or additional training deemed necessary during MBSS field sampling intervals.

3.4.3 Quality Control Officer

The QC Officer is responsible for implementation of all aspects of the MBSS QA/QC program, including inspection of field crews, data validation, taxonomic verification, site confirmation, calibration and maintenance of equipment, adherence to established protocols, and prompt identification of necessary remedial or corrective actions. The QC Officer is also responsible for oversight of laboratory QA/QC managers to ensure that all MBSS laboratory activities meet MBSS QA/QC requirements.

3.4.4 Field Crew Supervisor

The Field Crew Supervisor is responsible for day to day communication with Crew Leaders, coordination and approval of sampling schedules and itineraries, and other activities designated by the Project Officer.

3.4.5 Crew Leader

The Crew Leader is responsible for crew safety, sample scheduling, equipment maintenance and calibration, and performance of all sample collection activities in accordance with procedures and QA/QC requirements specified in the survey manual.

3.4.6 Field Sampling Crew

Members of the sampling crew are responsible for carrying out the instructions of the Crew Leader and informing the Crew Leader of any unsafe conditions, equipment, or other problems observed which could jeopardize the health and safety of the crew or the quality of sample collections.

3.5 TRAINING REQUIREMENTS

An important aspect of the MBSS QA program is the training program for field personnel which will be conducted prior to sampling. Training ensures consistent implementation of required procedures and attainment by each person of a minimum level of technical competency. All participants in MBSS field sampling must receive training as specified by the Project Officer. To verify the competency of MBSS crews, the QC Officer will conduct a one day visit with each crew prior to the Summer Index Period.

For personnel involved in sampling during the Spring Index Period, training will include water quality and benthic macroinvertebrate sampling using MBSS procedures. In addition, at least one member of each Spring sampling crew should be experienced in stream electrofishing techniques and approved as a benthic taxonomist by the Project Officer. For personnel involved in sampling during the Summer Index Period, training will include fish and herpetofauna sampling, habitat assessment, and taxonomy tests for fish, herpetofauna, and SAV.

3.6 FACILITIES AND EQUIPMENT

Preventive maintenance and calibration should be performed on all sampling equipment used as part of the MBSS. Maintenance and calibration procedures should be implemented as per manufacturers instructions. Unless otherwise specified, calibration should be performed daily prior to equipment use and anytime equipment problems are suspected. Preventative maintenance should be performed at intervals not to exceed the frequency recommended by the manufacturer. All equipment malfunctions should be fully corrected prior to reuse. For weighing scales, weekly checks should be conducted during field sampling using NIST standards or other accepted standards to demonstrate that instrument error is within limits specified by the manufacturer.

For each piece of equipment used as part of the MBSS, a bound logbook for calibration and maintenance should be maintained. Entries in the log should be made for all calibration and maintenance activities. Documentation will include detailed descriptions of all calibrations, adjustments, and replacement of parts, and each entry must be signed and dated.

To insure that MBSS equipment is operated within QA/QC requirements, the QC Officer should conduct periodic site equipment audits and promptly advise the Project Officer of any recommended corrective actions.

3.7 IMPLEMENTATION OF STANDARD OPERATING PROCEDURES

All of the standard operating procedures outlined in the MBSS sampling manual should be strictly followed. To insure that all procedures are properly implemented, the QC Officer should conduct periodic crew audits in the field. The audits should include: correctness in locating the sampling site, field technique evaluations, verification of taxonomic identifications, completeness of data sheets and field notebooks, calibration and maintenance log review, and health and safety critique of crew activities.

3.8 INFORMATION MANAGEMENT

A schematic of general information management procedures is shown in Figure 3-1.

3.8.1 Field Information Management

To facilitate data recording during inclement weather, data sheets should be printed on waterproof paper. Backup copies of all field data sheets should be made at the completion of each sampling week. Rolls of film for developing should be uniquely marked and separate, uniquely labeled bags used to send film for developing. When developed, film slides should be uniquely marked as well and stored at room temperature under dark conditions.

To ensure that all field data for the MBSS are collected and recorded in a usable manner, all data should be **PRINTED** in the units specified on the MBSS data sheets. No writeovers are permitted on data sheets-- the incorrect entry should be lined out and the correct entry written in an obvious spot next to the line out. Data sheets for a given site should be consecutively labeled so that the total number of data sheets generated for each site is known. Recorded data should be reviewed at the point of entry and the Crew Leader should review and initial all data sheets prior to departure from the site. Legible copies of all data sheets should be provided to the Data Management and Analysis (DM) Officer on a bi-weekly basis during sampling.

Each sample collected as part of the MBSS will be assigned a sample number. The sample number will contain several unique identifiers to minimize the possibility of misidentification. In addition, chain-of-custody forms should be maintained for all water sample collections.

3.8.2 Data Entry

To verify that all data collected at a sampling site is complete and acceptable, data entry of all data sheets will occur within 15 days after data sheets are received by the DM Officer. In the event that data is found to be unacceptable or incomplete, sampling can be repeated within the same index period. The DM Officer will maintain a bound logbook of all data entry information, and a back-up copy of all computerized data will be made and archived.

Data entry will be accomplished using entry screens designed to emulate data sheet format. Whenever possible, QA/QC checks will be embedded into data entry screens to ensure validity of data. All data will be double-entered using two different data entry operators and compared for consistency. Questionable data will be flagged and a determination of validity made by the DM Officer, the QC Officer, and the responsible Crew Leader. For all editing activities, full documentation of all changes is mandatory.

Automated review procedures such as range checks, frequency distribution of coded variables, and other internal consistency checks will be designed by the DM Officer and employed for data entry verification.

3.9 DATA QUALITY ASSESSMENT

Assessment of data quality against the established data quality objectives will be conducted to determine the overall performance of the QA program, identify potential limitations to use and interpretation of the data, and to provide information for other data users regarding usability of the data for other purposes.

The quality of MBSS data will be evaluated in several ways. Precision and bias associated with important elements of the sampling and measurement process for each variable measured will be evaluated using results from replicate sampling and performance evaluation studies. Information about precision, bias, and completeness will be used to determine the comparability of data acquired during each sampling year.

After data entry, verified data will be subjected to validation procedures to identify data values which are potentially erroneous. Various univariate and multivariate statistical procedures will be used on the verified data to identify outlying observations for which additional review is necessary.

At the end of each sampling year, specimens of all taxa collected must be verified by an appropriate recognized authority in fish, benthic macroinvertebrate, or amphibian taxonomy. Documentation of this verification should be included with the specimens as well as in tabular summary form. For benthic macroinvertebrates, the QC Officer will arrange for a random subset of at least 5% of the preserved benthic samples to be independently reprocessed in the laboratory. The QC Officer will prepare an annual written and tabular summary of all taxonomic-related QC activities.

As an additional measure of data quality assessment, scientific peer review of activities and products of the MBSS will be conducted at the direction of the Project Officer to help verify the technical soundness and utility of the data and its interpretation.

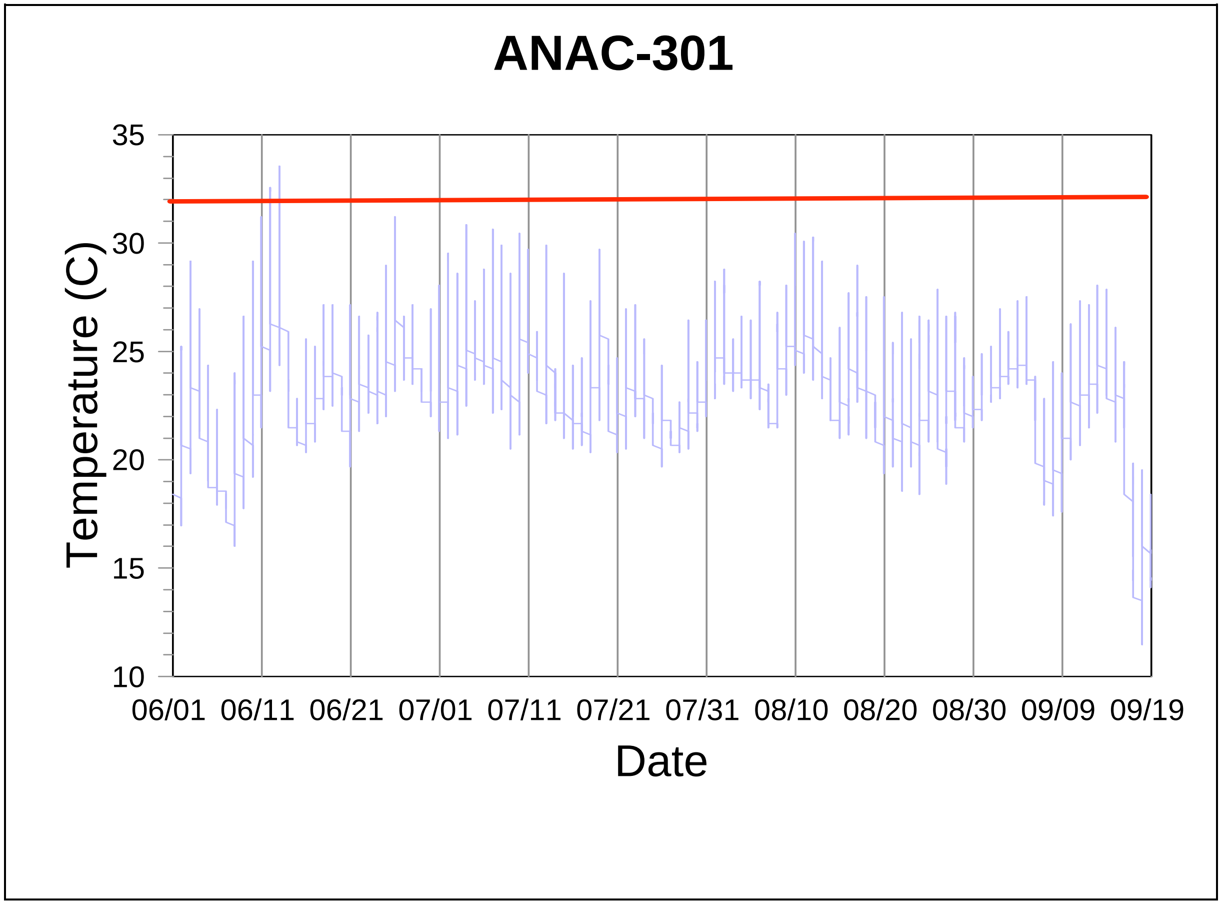
Appendix B1. Water chemistry measurements taken at Anacostia River sampling sites, reference sites, and the Big Elk Creek sampling site during Spring 1999 and 2000 ecological monitoring.

Site	Date Sampled	Closed pH	Specific Cond.	ANC (μµeq/L)	Chloride (mg/L)	Nitrate-N (mg/L)	Sulfate (mg/L)	Particulate Phosphorus (mg/L)	Total Dissolved Phosphorus (mg/L)	Ortho-phosphate (mg/L)	Nitrite (mg/L)	Ammonia (mg/L)	Total Dissolved Nitrogen (mg/L)	Particulate Nitrogen (mg/L)	Particulate Carbon (mg/L)	Dissolved Organic Carbon (mg/L)
ANAC-301	04/24/00	7.36	285.3	1038.3	44.281	0.971	17.769	0.0079	0.0086	0.0000	0.0000	0.0353	1.3609	0.0505	0.3999	2.844
ANAC-302	04/24/00	7.67	276.6	1092.4	40.662	0.947	17.300	0.0078	0.0169	0.0000	0.0000	0.0221	1.3592	0.0592	0.3554	3.131
ANAC-303	04/24/00	7.53	251.7	723.6	43.435	0.773	15.226	0.0067	0.0126	0.0000	0.0000	0.0428	1.2023	0.0443	0.3518	3.905
PRUT-201	04/25/00	7.11	234.7	611.3	41.211	0.524	16.255	0.1402	0.0195	0.0000	0.0000	0.1213	1.1106	0.4807	6.8291	4.849
MATT-305	08/24/99	5.70	79.00	32.1	5.68	0.61	15.48	N/S	0.0400	0.0400	0.0000	0.0200	0.9300	N/S	N/S	10.50
BELK-301	04/24/00	7.43	144.0	458.5	15.256	2.706	13.493	0.0026	0.0126	0.0000	0.0000	0.0388	3.2740	0.0405	0.3523	1.865

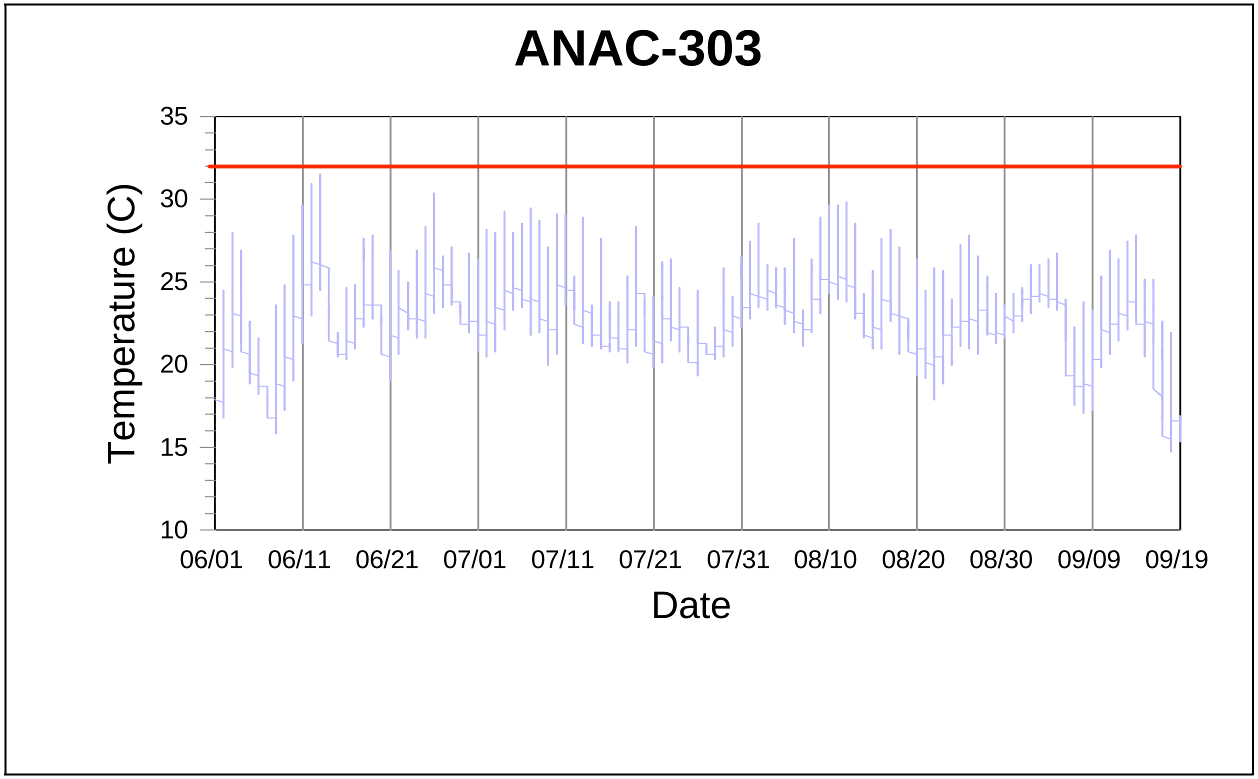
Appendix B2. Water chemistry measurements taken at Anacostia River sampling sites, reference sites, and the Big Elk Creek sites during Summer 2000 ecological monitoring.

Site	**Dissolved Oxygen (mg/l)**	**Temperature (°C)**	**Specific Conductance (μmhos/cm)**	**Turbidity (NTU)**	**pH**
ANAC-301	9.0	18.5	319	2.9	7.70
ANAC-302	9.9	21.0	310	2.7	7.36
ANAC-303	11.5	20.9	268	4.9	8.92
PRUT-201	8.2	25.4	322	7.4	7.61
MATT-305	7.6	22.0	117	8.5	6.58
BELK-301	7.9	21.8	181	4.8	7.56

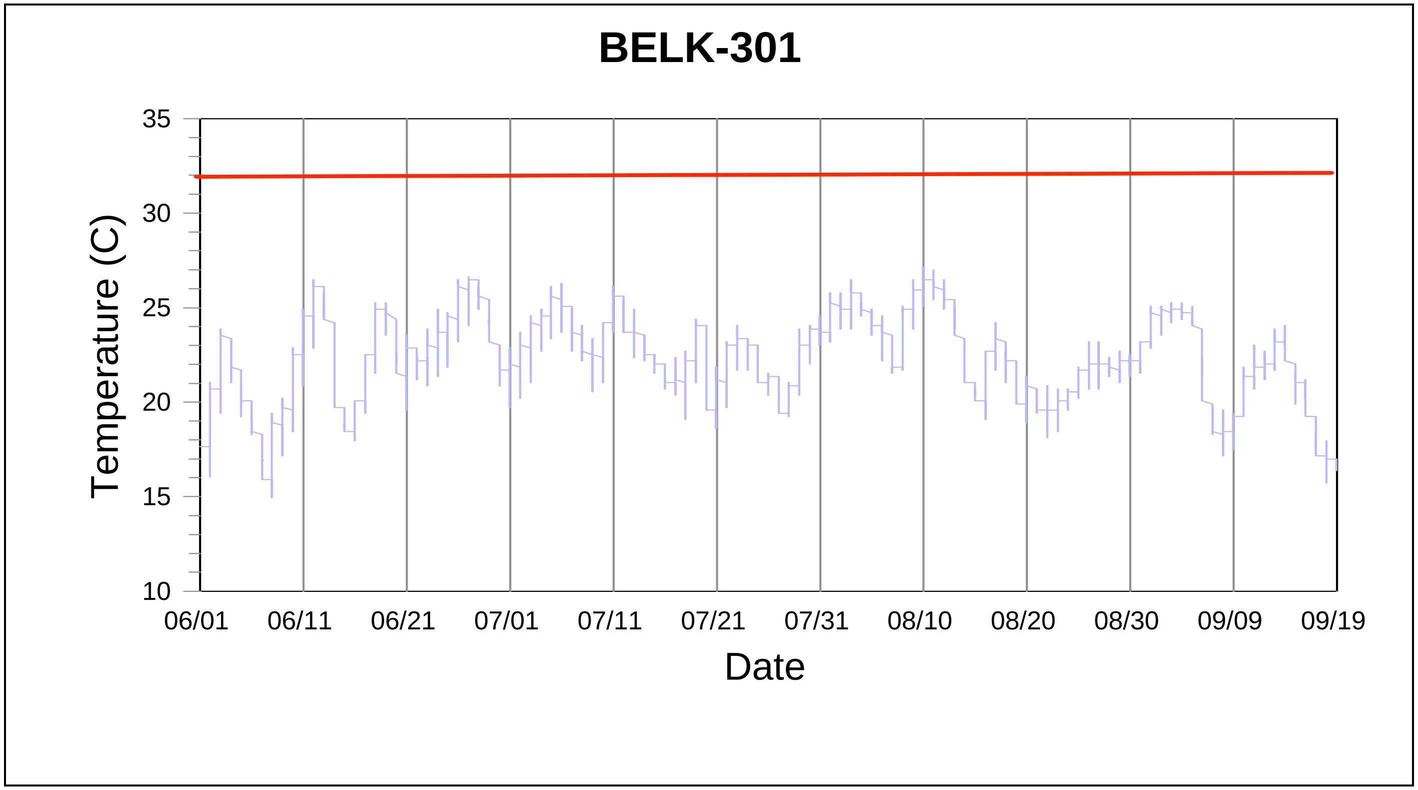
Appendix C1. Temperature logger data from site ANAC-301. Thirty two degrees Celsius is state water quality criterion for maximum temperature.



Appendix C2. Temperature logger data from site ANAC-303. Thirty two degrees Celsius is the state water quality criterion for maximum temperature.



Appendix C3. Temperature logger data from site BELK-301. Thirty two degrees Celsius is the state water quality criterion for maximum temperature.



Appendix D. Physical Habitat measurements taken at Anacostia River sampling sites, reference sites, and the Big Elk Creek site during 2000 ecological monitoring.

SITE	PHYSICAL HABITAT MEASUREMENTS													
	INSTRHA	EPISUB	VELDPTH	POOLQUA	RIFFQUA	CHANALT (R)	CHANALT (L)	EMBEDDE	EROSION (R)	EROSION (L)	SHADING	BUFFER (R)	BUFFER (L)	TRASH
	score	score	score	score	score	extent (m)	extent (m)	percent	extent (m^2)	extent (m^2)	percent	meters	meters	score
ANAC 301	7	2	7	13	0	75	75	60	0	0	5	25	20	5
ANAC 302	13	9	18	17	16	75	75	46	0	0	17	20	30	4
ANAC 303	8	11	11	11	14	75	75	60	0	1	6	0	0	5
PRUT 201	6	8	6	6	11	75	75	8	0	0	40	30	50	7
BELK 301	15	14	17	16	16	0	0	40	1	10	82	50	50	12
MATT 305	16	15	17	15	16	0	0	25	3	2	95	50	50	17

Appendix E. Fish species collected at Anacostia River, reference and Big Elk Creek sampling sites during 2000 ecological monitoring (N = Native statewide, IC = introduced to the Chesapeake drainage, IY = introduced to the Youghiogheny, I = introduced statewide, NA = no catagory assigned, T = tolerant, I = intolerant).

			SITE					
SPECIES	**NATIVE/ INTRODUCED**	**TOLERANCE LEVEL**	**ANAC 301**	**ANAC 302**	**ANAC 303**	**PRUT 201**	**MATT 305**	**BELK 301**
AMERICAN EEL	N	NA	54	42	95	24	36	94
BANDED KILLIFISH	N	NA	68	231	276	21	0	0
BLACKNOSE DACE	N	T	0	13	3	51	3	0
BLUEGILL	IC	T	4	2	4	1	29	4
BLUNTNOSE MINNOW	N	T	24	161	24	0	0	0
BROWN BULLHEAD	N	T	8	0	3	0	2	1
CENTRAL STONEROLLER	N	I	0	0	0	2	0	0
CHAIN PICKEREL	IY	NA	0	0	0	0	1	0
COMMON CARP	I	NA	2	1	0	0	0	0
COMMON SHINER	N	I	0	47	0	0	0	1
CREEK CHUB	N	T	0	0	0	18	0	4
CREEK CHUBSUCKER	N	NA	0	0	2	0	0	0
CUTLIPS MINNOW	N	I	3	23	0	0	0	0
E. SILVERY MINNOW	N	NA	0	54	0	0	0	1
EASTERN MUDMINNOW	N	T	0	0	0	0	11	0
FATHEAD MINNOW	I	NA	0	3	0	0	0	0
GOLDEN SHINER	N	T	8	1	0	0	0	0
GREEN SUNFISH	IC	T	10	1	0	0	0	0
LARGEMOUTH BASS	IC	T	0	1	0	2	2	5
LONGNOSE DACE	N	I	0	5	0	10	0	0
MARGINED MADTOM	IY	I	0	0	0	0	0	15
MOSQUITOFISH	N	NA	2	0	0	0	0	0
MOTTLED SCULPIN	N	I	0	0	0	0	0	21
MUMMICHOG	N	NA	48	115	175	10	0	0
NORTHERN HOGSUCKER	N	I	0	56	1	0	0	9
PUMPKINSEED	IY	T	57	5	24	0	4	2
REDBREAST SUNFISH	IY	I	453	132	202	15	0	18
SATINFIN SHINER	N	I	17	361	140	156	0	6
SEA LAMPREY	N	I	1	4	15	0	0	48
SILVERJAW MINNOW	N	NA	0	30	0	0	0	0
SMALLMOUTH BASS	IC	NA	0	1	0	0	0	5
SPOTTAIL SHINER	N	I	205	3117	78	0	0	0
STRIPED BASS	N	NA	0	4	0	0	0	1
SWALLOWTAIL SHINER	N	I	49	510	107	247	0	52
TADPOLE MADTOM	N	NA	0	0	0	0	3	0
TESSELLATED DARTER	N	T	11	572	18	22	9	68
WHITE SUCKER	N	T	158	110	8	0	0	50
WHITE PERCH	N	NA	0	0	0	0	0	1
YELLOW PERCH	IY	NA	1	0	0	0	0	0
YELLOW BULLHEAD	N	NA	12	20	24	0	3	0
Total			1195	5622	1199	579	103	406
total # of species			21	28	19	13	11	20

Appendix F. Benthic macroinvertebrates collected at Anacostia River sampling sites, reference sampling sites, and the Big Elk Creek sampling site during 2000 ecological monitoring. Tolerance levels range from 1 to 10 (1-3=least tolerant, 4-6= moderately tolerant, (7-10 = most tolerant, NA = no tolerance assigned).

TAXA	Tolerance level	ANAC 301	ANAC 302	ANAC 303	PRUT 201	MATT 305	BELK 301
		# found	# found	# found	# found	# found	# found
Ablabesmyia	8	2	0	0	0	1	0
Acentrella	4	0	0	0	2	0	2
Acerpenna	4	0	0	0	0	1	0
Brillia	5	0	1	0	0	0	0
Caenis	7	0	0	0	0	0	2
Calopteryx	6	1	0	0	0	0	0
Cheumatopsyche	5	0	1	0	0	63	0
COLLEMBOLA	NA	1	0	0	0	0	0
Conchapelopia	6	0	0	0	1	0	0
Crangonyx	4	2	0	0	0	0	0
Cricotopus	7	22	19	0	0	0	0
Cricotopus/Orthocladius	6	22	27	85	62	1	78
Dicrotendipes	10	0	0	0	1	0	0
ENCHYTRAEIDAE	10	13	0	0	0	0	0
Ephemerella	2	0	0	0	0	0	1
Eukiefferiella	8	0	0	0	0	0	1
GORDIIDAE	NA	1	0	2	0	0	0
Hemerodromia	6	1	0	0	0	0	0
HEPTAGENIIDAE	NA	0	0	0	0	7	0
Hydropsyche	6	0	0	1	0	9	0
Isonychia	2	0	0	0	0	0	2
Isotomurus	NA	0	0	0	4	0	0
Limnophyes	NA	1	0	0	1	0	0
LUMBRICULIDAE	10	1	0	1	0	0	0
Meropelopia	7	0	3	0	0	0	0
NAIDIDAE	10	6	23	0	0	0	2
Ormosia	NA	0	1	0	0	0	0
ORTHOCLADIINAE	NA	12	21	31	18	0	8
Orthocladius	6	0	0	0	0	0	3
Parametriocnemus	5	0	0	0	0	0	1
Peltodytes	5	1	0	0	0	0	0
Polypedilum	6	11	0	0	9	0	0
Potthastia	2	0	0	0	0	0	2
Prosimulium	7	0	0	0	0	1	0
PYRALIDAE	NA	0	0	0	4	0	0
Rheotanytarsus	6	0	0	0	0	3	0
SIMULIIDAE	7	0	0	1	0	0	4
Simulium	7	0	1	0	0	9	0
Smittia	NA	2	1	0	2	0	0
Stenelmis	6	0	0	0	0	16	1
Synurella	NA	0	0	0	0	1	0
Tanytarsus	6	0	0	0	0	2	1
Thienemanniella	6	0	0	0	1	0	5
TUBIFICIDAE	10	10	5	0	0	0	2
Zavrelimyia	8	1	1	0	0	0	0
TOTAL		110	104	121	105	114	115
NUMBER OF TAXA		18	11	6	11	12	16